SAGA

Strategies and Analysis for Growth and Access

SAGA Working Paper
December 2004

# Welfare Dynamics in Rural Kenya and Madagascar

Christopher Barrett, Cornell University

Paswel Phiri Marenya, Cornell University & University of Nairobi

John G. McPeak, Syracuse University

Bart Minten, Cornell University & National Center for Applied Research in Rural Development (FOFIFA) Antananarivo, Madagascar

Festus Murithi, Kenya Agricultural Research Institute, Nairobi, Kenya

Willis Oluoch-Kosura, University of Nairobi

Frank Place, World Agroforestry Centre, Nairobi, Kenya

Jean Claude Randrianarisoa, Cornell University & National Center for Applied Research in Rural Development (FOFIFA) Antananarivo, Madagascar

Jhon Rasambainarivo, National Center for Applied Research in Rural Development (FOFIFA)

Justine Wangilae, World Agroforestry Centre, Nairobi, Kenya

Strategies and Analysis for Growth and Access (SAGA) is a project of Cornell and Clark Atlanta Universities, funded by cooperative agreement #HFM-A-00-01-00132-00 with the United States Agency for International Development.

# Welfare Dynamics in Rural Kenya and Madagascar

Christopher B. Barrett,[a] Paswel Phiri Marenya,[a,b] John McPeak,[c] Bart Minten,[a,f] Festus Murithi,[d] Willis Oluoch-Kosura,[b] Frank Place,[e] Jean Claude Randrianarisoa,[a,f] Jhon Rasambainarivo[f] and Justine Wangila[e]

December 2004 revision

**Abstract:** This paper presents comparative qualitative and quantitative evidence from rural Kenya and Madagascar in an attempt to untangle the causality behind persistent poverty. We find striking differences in welfare dynamics depending on whether one uses total income, including stochastic terms and inevitable measurement error, or the predictable, structural component of income based on a household's asset holdings. Our results suggest the existence of multiple dynamic asset and structural income equilibria, consistent with the poverty traps hypothesis. Furthermore, we find supporting evidence of locally increasing returns to assets and of risk management behavior consistent with poor households' defense of a critical asset threshold through asset smoothing.

We thank Erin Lentz, Andrew Mude and Amare Yirbecho for valuable data assistance, Michael Carter, Angelique Haugerud, Peter Little and seminar participants at Cornell University for helpful comments, and our field assistants and survey respondents for their invaluable assistance in data collection and in helping us to understand the nature and dynamics of poverty in their villages. This work has been made possible, in part, by support from the United States Agency for International Development (USAID), through grant LAG-A-00-96-90016-00 to the BASIS CRSP, grants DAN-1328-G-00-0046-00 and PCE-G-98-00036-00 to the Pastoral Risk Management (PARIMA) project of the Global Livestock CRSP, and the Strategies and Analyses for Growth and Access (SAGA) cooperative agreement, number HFM-A-00-01-00132-00. The views expressed here and any remaining errors are the authors' and do not represent any official agency.

[a] Cornell University, Ithaca, NY, USA, [b] University of Nairobi, Kenya, [c] Syracuse University, Syracuse, NY, USA, [d] Kenya Agricultural Research Institute, Nairobi, Kenya, [e] World Agroforestry Centre, Nairobi, Kenya, [f] National Center for Applied Research in Rural Development (FOFIFA), Antananarivo, Madagascar

# Welfare Dynamics in Rural Kenya and Madagascar

## 1. Introduction

All development policy is based implicitly on a conceptualization of why people are poor and what interventions, if any, are needed to facilitate or accelerate their climb out of poverty. But the poor are a heterogeneous lot. Some people fall into poverty temporarily and are soon able to climb back out, while others are poor from birth or suffer a serious setback of some sort and stay poor for a long time thereafter. The latter two types of poor people may be ensnared in a poverty trap, while the former type retains economic mobility. Appropriate interventions may differ fundamentally according to the nature of the target subpopulation's poverty.

Under prevailing theories of economic growth and development, the poor enjoy higher marginal returns to productive assets than the rich do, so capital should flow disproportionately to the poor, enabling them to catch up economically. This follows logically from the standard simplifying assumption that there are diminishing marginal returns to assets in production. Moreover, this assumption implies that shocks cause merely temporary setbacks and that everyone enjoys the same latent opportunities. Under the prevailing orthodoxy, economic mobility should be enjoyed by all and persistent poverty should reflect merely a slow climb up from a low initial welfare level.

Under the poverty traps hypothesis, however, there exists a positive correlation – locally, albeit not necessarily globally – between wealth and rates of return on assets. This positive correlation is generated by (locally) increasing marginal returns to assets, in direct contrast to the standard simplifying assumption of globally diminishing marginal returns that underpins the prevailing orthodoxy. Regions of locally increasing marginal returns to assets can only exist in the presence of some mechanism that excludes some people with low initial conditions from accessing more remunerative livelihoods. Typically, exclusion occurs through restricted access to (formal or informal) credit or insurance necessary to build assets through investment and to protect them against loss or through socially exclusionary processes that limit certain groups' or individuals' access to preferred employment, credit or land. So latent opportunities are not identical for all. Furthermore, shocks can have permanent consequences when wealth is positively correlated with return on assets.

The policy implications of the poverty traps hypothesis therefore differ from those associated with mainstream models of welfare dynamics. In the presence of poverty traps, asset transfers, protection against shocks to productive asset holdings and removal of barriers that restrict the opportunities enjoyed by historically disadvantaged groups may matter as much as or more than exogenous improvements in productivity due to the endogenous productivity growth that may result from changes in asset holdings and accumulation and livelihood opportunites. Hence the importance of careful empirical research into the nature of persistent poverty.

This paper aims to contribute new micro-level evidence from rural Africa to enrich the debate surrounding the nature of economic growth and poverty dynamics. We use detailed panel data from several different sites in Kenya and Madagascar to explore the nature of poverty in novel ways.[1] By focusing on households' assets, the possibility of locally increasing returns to assets, and asset dynamics, we are able to show that multiple equilibria indeed exist in at least some places and to explore some reasons why this might be so. In doing so, we operationalize some of the suggestions of Carter and Barrett (2004).

[1] Several recent studies use an explicit growth model to study household-level dynamics (Ravallion and Jalan 1996, Gunning et al. 2000, Elbers et al. 2002, Jalan and Ravallion 2002, 2004, Deininger and Okidi 2003, Dercon 2004). Yet none seeks to test among competing hypotheses of the underlying growth mechanism, as Carter and Barrett (2004) argue is necessary. Most simply impose a variant of the classic Solow model. Our approach imposes no model of the underlying growth mechanism.

The remainder of the paper proceeds as follows. Section 2 provides a brief background on Kenya and Madagascar, then describes the data we use and the settings from whence they were collected in rural Kenya and Madagascar. The sampling strategy was designed to generate informative variation in agroecological and market access conditions so as to explore the possibility of geographic poverty traps. Section 3 then presents standard evidence on economic mobility and poverty dynamics in our survey villages. Section 4 then uses more innovative empirical methods to explore the possibility that poverty traps indeed exist, as reflected in structural income and asset dynamics. Section 5 then investigates some possible explanations as to why poverty traps appear to exist in some of our sites. Section 6 briefly draws out a few keye policy implications of these findings.

## 2. The Settings and the Data

### A) Poor Countries With Liberalized Markets

Kenya and Madagascar are both poor, rural African nations that underwent relatively dramatic market-oriented reforms beginning in the latter half of the 1980s. They had followed nearly-opposite post-independence trajectories for the 20-25 years prior to the onset of economic liberalization. Kenya had long been the most considered the most vibrant economy in east Africa, a former British colony that was home to the largest urban market (Nairobi) between Cairo and South Africa and to a wide range of modern agricultural and industrial producers who took advantage of the country's climate, soils and physical and social infrastructure that were well above sub-Saharan African norms. Madagascar, on the other hand, was a former French colony that enjoyed twelve years of relatively successful, liberal economic rule similar to

Kenya's before a Marxist dictatorship took over in 1972, imposing a state-controlled, inward-looking economic system explicitly modeled on the Democratic People's Republic of Korea.

The differences between the two countries mask, however, important similarities. Both countries encompass remarkable variation in agroecological conditions, from desert to humid rainforests to rugged highlands, from whence the ruling elites of both countries have hailed. Natural disasters – drought, floods and cyclones – ravage parts of both countries regularly and disease is widespread, confronting poor populations with considerable risk. Moreover, in spite of the stark differences in their early post-independence histories, both countries suffered serious balance of payments, external debt and fiscal deficit problems in the 1980s that necessitated reforms under the aegis of structural adjustment programs underwritten by the International Monetary Fund and the World Bank. In spite of 10-20 years of sometimes-halting reforms, the consensus among domestic and foreign observers is that getting the macro economy "right" has failed to stimulate broadly based, sustainable economic growth. Poverty has increased in both countries over the past decade. The variation in their histories and their shared recent experience of market-oriented policy reforms that appear not to have made an appreciable dent in poverty make Kenya and Madagascar as a pair a reasonable microcosm for much of sub-Saharan Africa.

B) Data Description

The data we use were collected through the "Rural Markets, Natural Capital and Dynamic Poverty Traps in East Africa" project of the USAID BASIS CRSP.[2] We opportunistically constructed household-level panel data sets in five different sites in rural Kenya and Madagascar, building on previous surveys conducted by our team. In order to control for the possibility of exogenous variation in welfare status and dynamics due to agricultural potential, access to

[2] For more information, see the project web site at http://afsnrm.aem.cornell.edu/basis/ or the BASIS CRSP web site at http://www.basis.wisc.edu/ .

commercial markets, or both, sites were selected to cover each cell of a matrix reflecting better or worse market access on one axis and a better/wetter or worse/drier agroecology on the other. Between-sites variation in observed welfare dynamics thus helps us explore the possibility of geographic poverty traps. Meanwhile, the within-site variation according to endogenous household attributes such as wealth enables us to explore the possibility of poverty traps associated with multiple equilibria at household level.

Our highest potential sites enjoy sufficient water to sustain sedentarized livestock and high-value horticulture and tree crops year-round and good enough access to markets to be able to engage in high frequency (daily or semi-weekly) commercial transactions. We have one such site in the central highlands of Madagascar: the Vakinankaratra region around Antsirabe and Betafo, about three hours' drive from the capitol city, Antananarivo, on a macadam highway (Figure 1). There we resurveyed 94 households previously surveyed in 1997.

Our sites with greater agroecological potential but limited market access likewise have adequate rainfall to sustain multiple crops over the course of the year, but while access to secondary cities is adequate, it is a day or more's drive to the nation's principal commercial markets. In western Kenya, we resurveyed 89 households that had originally been surveyed in 1989 in Madzuu location in Vihiga District. The "wetter-worse" site in Madagascar is in the southern highlands, in Fianarantsoa province, where we resurveyed 58 households previously visited in 1997.

We had no Malagasy sites with poor agroecological potential for which we also had suitable baseline data on which to construct a panel. So our "drier" sites are all in northern Kenya. In lower Baringo District, a semi-arid region that nonetheless enjoys reasonable water access through Lake Baringo and the Pekerra River and the national irrigation scheme along the

River before it empties into the Lake, we surveyed 30 households on a quarterly basis from March 2000 through June 2002, in Ng'ambo location. This site is less than two hours by all-season road from the secondary city of Nakuru and only half a day's drive from Nairobi. Our most remote, semi-arid site is Dirib Gombo, eight kilometers from Marsabit town in the eponymous dryland Marsabit District of northern Kenya, 540 kilometers from Nairobi, roughly half of that distance without a macadam road. The sample size and survey instruments and frequency were identical in Ng'ambo and Dirib Gombo, as they were part of a broader survey of six sites in northern Kenya (and five in southern Ethiopia) begun by the Pastoral Risk Management (PARIMA) project of the USAID Global Livestock CRSP. Agro-pastoralism predominates in both Ng'ambo and Dirib Gombo, with extensive grazing combined with rainfed crop cultivation (and limited irrigated agriculture in Ng'ambo) and some nonagricultural activities, especially for Ng'ambo with its superior market access.

Each site's baseline survey was designed for a different purpose and thus the data are imperfectly comparable across sites, although we took great care to ensure consistency across survey periods within each site. The Ng'ambo and Dirib Gombo sites are the only ones for which we have many periods' observations, so they are the only ones for which we can study high-frequency intertemporal variation. Because of these inconsistencies across data sets, the comparisons made in sections 3 and 4 are necessarily partial between sites and we focus mainly on intra-site variation among households. We use income data for comparative quantitative analysis because good expenditure data are not available for all five sites.[3] But we intentionally use multiple quantitative and qualitative methods as a check on robustness, as a way to tailor the

[3] Different metrics – expenditure, income, anthropometric status, etc. – can yield different measures of chronic and transitory poverty. See Place et al. (2003) for a demonstration of this point using data from western Kenya.

measure to the question at hand, and to play to what we perceive as the relative strengths of different data sets.

The resurveying interval varies markedly across sites as well. As we discuss in the next section, this variation, from the high frequency, short 2000-2002 panel in northern Kenya, through the intermediate five year panels in Madagascar to the low frequency, 1989-2002 panel in western Kenya, enables a suggestive look at how time affects economic mobility and inference about the persistence of poverty. Each site's panel suffered attrition as households that were in an early round disappeared, were unwilling to be surveyed again or otherwise fell out of the sample by the later round(s). We attempted to control for prospective attrition econometrically in each site's data, but could not establish any robust statistical pattern, suggesting that concerns about attrition bias do not seem serious in these data.[4]

Our meta-data set of 301 households also spans the full range of rural poverty rates in the two countries. The Vakinankaratra site lies in the highest potential region and has one of the lowest poverty rates in Madagascar. In contrast, the Dirib Gombo and Fianarantsoa sites are located in resource scarce areas of the two countries, and have headcount poverty rates well above 80 percent. (Kenya Ministry of Planning 1998, Minten and Zeller 2000). The intermediate potential sites in Baringo and Vihiga Districts lie between these extremes.

Finally, we followed up the panel survey data collection with qualitative poverty appraisals in each site. This involved both community-level focus group meetings and key informant interviews to establish local conceptualizations of poverty and community-level phenomena that have affected the observed trajectories of most households. We followed up

[4] We used probit and logit models to estimate the probability of attrition from the survey conditional on households' initial characteristics. For a range of different explanatory variables, we could never come up with a regression specification that yielded a p-value of less than 0.09 on the test of the null hypothesis that the full set of regressors are uncorrelated with sample attrition. Alderman et al. (2001) and Falaris (2003) similarly found that attrition bias is not a serious concern in other developing country panel data sets.

these group meetings with in-depth case studies of selected households so as to construct social-historical profiles of distinct household types characterized by observed welfare transitions. We constructed household-level per capita income transition matrices – discussed in the next section – for each site in order to establish which households had been poor in each survey period, which had exited poverty from one round to the next, which had fallen into poverty between survey rounds, and which had consistently stayed non-poor. We then further broke down the subsamples in each site who remained poor in both periods and those who were nonpoor in both periods according to the direction of change in their income between periods: those with significant per capita income losses between periods, no significant change, and those who enjoyed significant per capita income gains from one survey round to the next. We did intensive household level oral histories for two sample households from each site in each of those eight transition matrix groups. In those interviews – and subsequent closing community meetings – we focused especially on understanding the historical context underpinning local households' strategies to improve their welfare and the pathways by which certain households collapse into or escape from poverty.

## 3. Income Mobility and Poverty Dynamics in Rural Kenya and Madagascar

We begin the empirical analysis by offering simple descriptions of intertemporal income mobility and poverty transitions by site, what Carter and Barrett (2004) refer to as second generation poverty analysis, before we move into asset-based poverty measures, or what Carter and Barrett term fourth generation poverty measures, in the next section.

### A) Income Transitions

Per capita income transition matrices offer perhaps the simplest way of depicting economic mobility, in that they summarize intertemporal movement relative to an income poverty line. In order to be able to compare households across periods and countries, we established a common poverty line. We use an ultra-poverty line of US$0.50 per capita per day in real 2002 US dollars. This ultra-poverty line is reasonably close to (and roughly equidistant from) the relevant official poverty lines. Kenya's rural poverty line of KSh1,238/month per capita is equivalent to about US$0.53/day, while the official Malagasy poverty line of FMG988,600 equals about US$0.43/day per person.[5] We converted each period's local currency observations into U.S. dollars using the period-specific exchange rate and, lacking proper deflator series for these rural communities, used the U.S. GDP deflator to convert all nominal figures into real terms under the maintained hypothesis of constant real exchange rates. Table 1 presents the resulting real daily per capita income transition matrix.[6]

The sample proportions that were poor in each survey period are greatest in the "drier-worse" site of Dirib Gombo (northern Kenya), where every household's per capita daily income fell below $0.50 in each period, and least in the "wetter-better" site of Vakinankaratra (Madagascar's central highlands), where only 58.5 percent fell below the ultra-poverty line in each survey period. The population shares that were poor in both the initial and subsequent period also decrease as one moves in either the direction of better agroecology or better market access. Similarly, the population share that was non-poor in both the initial and subsequent survey periods increases as one improves agroecological conditions, market access, or both. Overall, more than 70 percent of our aggregate sample fell below the $0.50 daily per capita

[5] Prevailing exchange rates in 2002-3 are roughly 75 Kenya shillings and 6200 Malagasy francs per U.S. dollar.
[6] Income measures were constructed the same way for each site. Income equals net cash income (wages, salary, earnings from farm and nonfarm enterprises, transfers, remittances, interest on savings, rental income from properties owned, etc.) plus the cash value of home-consumed food production (including milk and meat from slaughtered animals), valued at prevailing annual average, village-specific market prices for the goods in question.

income ultra-poverty line in each survey period, and less than one-quarter crossed the poverty line between survey rounds, with overall ultra-poverty remarkably stable at 82 percent since 11.3 percent fell into poverty while an almost-identical 11.2 percent climbed out. There is mobility around the poverty line, but it is essentially offsetting in that one household is replacing another.[7] The overwhelming majority of households in our sites are persistently ultra-poor.

This simple transition matrix suggests two key results, although one must be cautious about overinterpreting such figures since they are not statistically representative of either nation, much less of broader aggregates of low-income countries, and because the time periods of the surveys do not coincide perfectly. First, there is non-trivial entry into and exit from poverty in several of our sites. Even in very poor places, some people commonly escape while others fall into poverty, consistent with the mounting evidence on the extent of transitory poverty (Baulch and Hoddinott 2000). Second, there seem to be distinct geographic patterns, with sites with poorer agroecological conditions and market access exhibiting greater and more persistent poverty than sites in more favorable settings. This is consistent with the idea of geographic poverty traps.

B) Poverty Exit Rates

Annual poverty exit rates offer another way to gauge poverty persistence. One can estimate the annualized poverty transition probability, m, or conversely the annual exit rate, 1-m, from

$$PR_t = m^t \, PR_0 \qquad (1)$$

where, $PR_0$ is the poverty rate in the baseline period and $PR_t$ is the poverty rate in a future period t years hence. With just two data points, this computation becomes simply arithmetic. With multiple data points, one estimates m by regressing the logarithm of the $PR_t$ series on a time

[7] Krishna et al. (2004) similarly find symmetry between entry into and exit from poverty (around 19% for each category) over a 25 year span in their study of western Kenya.

index t; the natural logarithm of $PR_0$ becomes the regression constant. When $PR_t$ reflects the sample proportion that was poor at time 0 and remained poor at time t, 1-m represents a gross exit rate. When $PR_t$ includes households that have fallen into poverty since time 0, we have a net exit rate, i.e., those who became nonpoor less those who became poor.

Table 2 presents gross and net poverty exit rate estimates for our five sites. With the exception of the Ng'ambo site, where a small sample and a short panel period that began in the midst of an uncommonly severe drought likely inflate the estimated poverty exit rate, the net exit rates are no greater than 1.0 percent of the population per year and the gross exit rates are uniformly less than 2.5 percent per year. The negative estimated exit rate for the Vakinankaratra likely reflects the fact that the second round of panel data was collected immediately following a debilitating seven-month national crisis precipitated by a disputed presidential election that led to national strikes, fuel shortages and infrastructure damage. The poverty exit rate estimates, unlike the transition matrices, reveal no clear correspondence between agroecological potential or market access and household-level economic growth. Given that at least two-thirds of the sample in each site fell below the ultra-poverty line in each period of our surveys, these low estimated exit rates underscore the persistence of poverty in rural Africa. Graduation from ultra-poverty comes slowly at best.

## 4. Stochastic versus Structural Welfare Dynamics

### A) Stochastic and Structural Income Dynamics

As Carter and Barrett (2004) explain, there is a major weakness in these second generation approaches to studying economic mobility. They cannot distinguish whether a household exits poverty because they accumulate productive capital, because the productivity of their assets permanently improves – either of which would suggest a structural transition and that they should remain non-poor thereafter – or if they merely enjoyed a transitory windfall – in which case they would likely soon fall back below the poverty line. Similarly, it matters whether someone entered poverty due to permanent asset loss (e.g., injury, death of prime-age worker, loss of land or livestock) or because of transitory events (e.g., a job change, temporary illness). In order to address this shortcoming, one must study the structural underpinnings of poverty and poverty transitions directly.

Transitory variation – for example, due to seasonality or short-lived shocks – and measurement error loom large in income (or expenditure) data. As a result, much of any period's observed income is stochastic. That necessarily clouds inference about the structural patterns of welfare dynamics. This can perhaps be seen most easily by considering a simple decomposition of income for household i at time t,

$$Y_{it} = A_{it}`[r_{it}(A_{it}) + \varepsilon^{R}_{it}] + U_i + \varepsilon^{T}_{it} + \varepsilon^{M}_{it} \qquad (2)$$

where Y is measured income,[8] A is a vector of productive assets (labor, land, livestock, etc.) used to generate earned income, r is the corresponding vector of expected returns per unit asset held, which may depend systematically on the household's asset holdings, $\varepsilon^R$ reflects period-and-household specific returns (i.e., yield and price) shocks, U captures household-specific but time invariant unearned income flows (e.g., the time invariant component of pensions or transfers), $\varepsilon^T$ represents transitory unearned income (e.g., period-specific deviations from mean transfer volumes) , and $\varepsilon^M$ is measurement error. Each of the stochastic components, $\varepsilon^M$, $\varepsilon^R$ and $\varepsilon^T$ is zero mean and independently and identically distributed over time. Expected period-specific income

[8] One can substitute expenditures for income and repeat the analysis exactly, except that one then must account for endogenous savings. The income-based version is simpler and yields qualitatively identical results.

– or what Carter and May (2001) or Carter and Barrett (2004) term "structural income" – is therefore just

$$E\{Y_{it}\} = A_{it}`r_{it}(A_{it}) + U_i \tag{3}$$

Assets vary in importance among households. In rural Africa, the poorest households typically rely heavily on unskilled agricultural labor markets; labor power comprises the vast majority of their productive asset stock (Barrett et al. 2001, Jayne et al. 2003). Wealthier households commonly rely more heavily on earnings from land, livestock and skilled employment (e.g., salaried labor or skill-or-capital-intensive nonfarm enterprises). Hence the importance of thinking about A in equation (2) above as a vector of assets.

Growth in observed income can be represented by totally differentiating equation (2)

$$dY_{it} = dA_{it}`[r_{it}(A_{it}) + \varepsilon^{R}_{it}] + A_{it}`[dr_{it}/dA_{it} + d\varepsilon^{R}_{it}] + d\varepsilon^{T}_{it} + d\varepsilon^{M}_{it} \tag{4}$$

Taking the expectation of equation (4) determines the expected change in income, or the structural income dynamics of the household,

$$E\{dY_{it}\} = E\{dA_{it}\}`r_{it}(A_{it}) + A_{it}`E\{dr_{it}/dA_{it}\} \tag{5}$$

Equation (5) highlights that income growth depends on changes in productive asset holdings and on changes in rates of return on assets. A household's assets evolve according to its accumulation behavior and asset shocks. Expected returns on assets evolve according to exogenous changes in prices and productivity and changes in one's asset holdings.

The latter point is central to poverty traps based explanations. The existence of multiple equilibria implies nonlinear returns on assets. Multiple dynamic equilibria can only exist if there exist locally increasing returns at some point(s), i.e., $dr/dA_{|A=A*} > 0$ at some asset level(s) A*. This points us toward a natural empirical test for poverty traps that we undertake later.

The preceding equations equip us to investigate the implications of the considerable stochasticity of income in these sites. If we simply regress the period-on-period change in income, $dY_{it}$ on beginning period income, $Y_{it}$, then we necessarily incorporate intertemporal change in transitory unearned income, in the stochastic component of returns on assets, and in measurement error. Each of these will necessarily generate a regression-to-mean effect, a negative correlation between income change and beginning period income, controlling for the effects due to $dA_{it}$ and $dr_{it}/dA_{it}$, which could be either negative or positive. In other words, if the stochastic components are serially independent, good draws in one period are typically offset by poorer draws in subsequent periods and vice versa. Just as the stochastic component of income tends to exaggerate income inequality in cross-sectional analyses, so too does it generate spurious economic mobility in longitudinal analyses.

The best approach to studying long-term dynamics, therefore, is to focus on structural income dynamics and the underlying dynamics of households' assets. One way to do this is to regress the expected change in income on structural income, as reflected in equation (3). This approach necessarily focuses on just the structural (i.e., nonstochastic) components of income and income dynamics.[9] If one is interested in the problem of persistent poverty, then these structural income dynamics are the portion of income on which one needs to focus, not on total income dynamics that necessarily include measurement error and transitory shocks that one would expect to be reversed in time.

To demonstrate the difference between the two methods, we estimated both total income dynamics and structural income dynamics regressions for each site. If economic opportunities are open to all and returns on assets are globally diminishing, as prevailing theories hold, then

[9] Carter and May (2001) explain and demonstrate the importance to poverty analysis of this distinction between the stochastic and structural components of income.

one should find a negatively sloped relation between income change and base period income, with the curve crossing the zero change threshold just once, at the point towards which all households converge.  By contrast, under the poverty traps hypotheses, the regression relationship need not be monotonically negatively sloped.  Rather, it will cross the zero income change line around each dynamic equilibrium toward which households converge, with the stable (unstable) equilibria occurring where the regression line crosses the zero expected change point with negative (positive) slope.

Figure 2 presents these income change regressions for each site.[10]  The dashed lines reflect the nonparametric regressions[11] of the total income change on beginning period income.  For each of the five sites, the estimated slope is negative over most or all of the conditioning domain and the regression line intersects the (horizontal) zero change line from above at just a single point, as prevailing theory hypothesizes.

However, when one strips out the noise due to the stochastic component of income and looks at the estimated structural income dynamics of these households, the results change strikingly. To estimate household-level structural income dynamics, we estimated equation (3) via a simple ordinary least squares regression of income on a vector of assets appropriate to each site and period-specific dummy variables for each survey village, pooling observations across periods.[12]

---

[10] Note that the axes are not scaled identically across sites, given differences in ex ante income distributions.

[11] A locally-weighted scatter plot smoother  (LOESS or LOWESS) regression generates a series of conditional means over a fine grid on the conditioning domain (i.e., the independent variables) by fitting a weighted linear regression, where the weights decrease with distance from the point of interest. We connect these predicted values to produce a (potentially highly nonlinear) curve. The key parameters affecting the estimated regression curve are the span or bandwidth, which determines how many nearby observations are used in predicting the dependent variable at a given point, and the degree of the regression, whether it is locally linear or quadratic.  We use second degree (i.e., quadratic) LOESS estimators with optimal, variable span (based on cross-validation) on this and all subsequent nonparametric regressions.

[12] With enough household-specific observations over time, one could properly estimate $U_i$, the time-invariant household-specific component of income from equations (2) and (3).  In practice, we typically haven't enough longitudinal observations on single households to retain sufficient degrees of freedom in estimation if we include these household fixed effects.  We therefore opt here for village-specific fixed effects.  In Madzuu, the assets used as regressors are farm size, improved dairy cattle, unimproved dairy cattle, nondairy cattle, small ruminants (sheep and

The coefficients on the individual assets reflect the expected rates of return, r, while the coefficients on the site-and-period-specific dummy variables summarize the exogenous change in expected rates of return holding asset stocks constant, dr, and the conjectured time-invariant level of unearned income, U. We study the resulting estimates of r in a bit more detail in the next section. We generate expected change in income by using households' assets stocks in the first and last periods of the panel data to predict structural income in each period, then take the difference between them.

The solid lines in Figure 2 reflect the nonparametric structural income dynamics regressions. Unlike the total income dynamics regressions, these lines are not monotonically negatively sloped. Except for Dirib Gombo – where no household graduated from poverty in our survey period (Table 1) – each of the site-specific structural income dynamics regressions exhibits multiple dynamic equilibria, as reflected by points where the regression line crosses the zero change line from above. In each site, one such equilibrium lies below the ultra-poverty line of $0.50/day per capita, suggesting no expectation of a graduation out of poverty if one relies merely on the natural dynamics of the extant system. These regressions of expected income changes on base period structural income are consistent with the poverty traps hypotheses.

Our qualitative studies among these households echo this general impression that there exist multiple equilibria. Throughout the Kenya sites, community focus groups told us repeatedly that

---

goats), poultry, farm and business equipment, household demographic composition (size, ages, gender), dummies for educational attainment categories for the household head and for the most educated member of the household, distance to nearest market, bicycles owned, and dummy variables for receipt of credit, being native to the village, and for 2002 (to capture period-specific shocks to aggregate returns). The equation fitting income on a linear function of these asset variables had an adjusted $r^2$=0.34. In the two Malagasy sites, we used the same regressors as in Madzuu, minus small ruminants and poultry, but adding number of hogs, bank savings and dummy variables for extension service access and villages, and breaking total farm land into lowland rice fields and all other agricultural lands. In Dirib Gombo and Ng'ambo, we used the Madzuu regressors, dropping improved dairy cattle (irrelevant in these sites) and whether the respondent was native to the village (the variable is absent from the northern Kenya data sets). The adjusted $r^2$ on the Fianarantsoa, Vakinankaratra, Baringo and Marsabit regressions were 0.43, 0.44, 0.37 and 0.28, respectively. The modest explanatory power of these regressions, given small sample sizes that would typically yield high $r^2$ statistics, reinforces the point that much household-and-period-specific income appears stochastic rather than structural.

poverty has increased in our survey communities and that the time it takes for a household to recover from an adverse shock or to exit poverty has increased over the past ten to twenty years. Although local definitions of poverty vary across the sites, in both community focus group interviews and in depth oral histories of individual households, respondents in Dirib Gombo, Madzuu and Ng'ambo all explained increased poverty and reduced economic mobility as arising due to greater environmental variability and lower average rainfall, poorer quality soils due to less frequent fallowing and reduced manure application, decreasing per capita holdings of land and livestock, increasing difficulty in finding remunerative employment for educated adults, and the decline of informal support networks to help in response to temporary health and income shocks (Mango et al. 2004).

Interestingly, those who are continuously nonpoor or who were poor but exited poverty in our samples commonly offer stories consistent with prevailing theories of economic growth. Meanwhile, the current poor – whether they became poor during the survey period or had always been poor – describe poverty dynamics in a fashion far more consistent with the hypothesis of poverty traps. Inference from above the poverty line plainly differs from the perspective from below.

The currently nonpoor frequently emphasize individual attributes – most notably work ethic and drunkenness – as leading to fundamentally different stations in life. By their view, those without the discipline to refrain from excessive alcohol consumption and to work hard stay poor, while their more self-disciplined neighbors exit poverty and then remain nonpoor. This is essentially a story of convergence to a group-specific equilibrium, with little hope of people changing groups.

By contrast, the currently poor emphasize the difficulty of asset accumulation and the central role of asset losses in explaining patterns of mobility. Every one of the households we interviewed who were poor in the most recent period could trace their poverty ultimately to some asset shock, whether before or after the first round of our surveys. Serious human health shocks causing permanent injury or illness or death were the most frequently cited reasons for households falling into poverty (Mango et al. 2004, Randrianjatovo 2004).[13] Some adverse effects are direct, as when economically active household members fell ill and subsequently had to stop working or even died and their earnings were lost or their absence came at a critical time in the cropping cycle, causing them significant seasonal losses from which they have been unable to recover. Other effects respondents mentioned frequently are indirect, as when children had to be pulled out of school for want of school fees due to the high costs of treating illness or funeral expenses, or when the family lost productive draught power, manure or milk production when it had to undertake ritual slaughter of livestock for a funeral.

The poor routinely point to certain activities – e.g., zero-grazing dairy production with improved (cross-bred) cows, commercial tea cultivation, salaried employment based on above-average educational attainment and social connections – as higher-return activities that lie beyond their reach for want of start-up capital to buy improved cattle or tea bushes, or due to a lack of education or the connections to land a good job. Several people mentioned the importance of migration as an escape route. Young, educated people who can move to better land or to cities where they can find a good job enjoy some prospect of escaping the persistent rural poverty toward which they otherwise seem headed. Parents frequently invest heavily in educating their children in the hope that they can indeed win the skilled employment lottery in a

[13] This echoes other qualitative work on poverty dynamics undertaken in the eastern escarpment of Madagascar (Freudenberger 1998), western Kenya (Krishna et al. 2004, Kristjanson et al. 2004) and India (Krishna 2004).

city and eventually provide financial support back home. But the personal connections necessary to land a good job and the capital necessary to start small businesses are perceived as major obstacles to be overcome by poorer families. The poor's perception is that barriers to entry into more remunerative activities dampen their labor, land and livestock productivity relative to their nonpoor neighbors. Meanwhile, their considerable exposure to risk of asset loss – due to human or livestock disease, theft or natural disasters – leaves them reticent to undertake activities that might further increase those risks. We return to this risk management theme below.

The qualitative descriptions offered by our respondents to explain their own welfare dynamics mirror the quantitative evidence. Between site variation in ultra-poverty rates and rates of exit from poverty suggest that poverty is lower and exit faster where market access and the basic agroecology are more favorable. This creates significant migration incentives. There nonetheless remains considerable intra-community variability in welfare status.[14] One needs to guard against geographic determinism in explaining patterns of persistent poverty. Furthermore, within sites, where we focus, there appear to be multiple equilibria toward which household incomes converge, providing empirical support to the hypothesis that poverty traps exist.

B) S-Shaped Asset Dynamics

Because assets generate income, asset dynamics underpin structural income dynamics. We therefore also study asset dynamics in order to understand structural income dynamics better in these rural Kenyan and Malagasy communities. If the return on assets increases with ex ante wealth over at least some portions of the wealth distribution, then one would naturally expect this to lead to asset accumulation. Then, as the returns on asset diminish, accumulation slows, leading to a stable dynamic equilibrium where asset stocks remain stable over time. When

[14] Jayne et al. (2003) find similar patterns using nationally representative survey data from several eastern and southern African countries. Mistiaen et al. (2002) have similar findings in their poverty mapping study of Madagascar.

returns on assets are increasing only locally, however, there may be multiple stable dynamic equilibria, consistent with the notion of a poverty trap.

Multiple stable dynamic equilibria imply nonlinear asset dynamics, more precisely S-shaped dynamics when one plots future assets against current assets. Lybbert et al. (2004) found such patterns in southern Ethiopian pastoralist communities very similar to the northern Kenya sites in our study. There seem to be multiple stable dynamic herd size equilibria in our northern Kenya sites, as well. Figure 3 depicts the nonparametric regression of herd size (the solid line without markers), measured in tropical livestock units (TLU)[15] per capita, a useful scalar measure of wealth in pastoralist communities, on the previous quarter's herd size, pooling the Dirib Gombo and Ng'ambo observations together to improve precision.[16] The dashed diagonal line depicts dynamic equilibria. The expected asset dynamics exhibit stable equilibria – points at which the regression line crosses the dashed diagonal line from above – at approximately 0.2 and 10 TLU per capita. Translated into somewhat more concrete units, a median household of six persons faces both a low-level equilibrium herd size of about one cow or 10-12 goats or sheep, or a higher stable equilibrium herd size on the order of 50-60 cattle.

There exists one unstable dynamic equilibrium between these two stable dynamic equilibria. This nonparametric regression suggests that household-level herd dynamics bifurcate at 5-6 TLU per capita. Above that level, the herd size naturally grows toward the higher equilibrium of 10 TLU per capita. But below the unstable equilibrium, household herd sizes tend to collapse toward the low-level equilibrium of less than one TLU per capita. This suggests that 5-6 TLU

[15] The TLU represents a standardized measure of metabolic liveweight in animals, enabling aggregation across species according to the formula 1 TLU = 1 cattle = 0.7 camels = 10 goats = 11 sheep.

[16] We also ran these regressions separately for each site and found no statistically significant difference between the two sites in herd dynamics, thus justifying combing the data from the two sites.

per capita demarcates a critical threshold that northern Kenyan pastoralist households and those interested in their welfare need to defend that threshold vigorously.[17]

We need to be careful, however, about investing too much in the estimates that result from the simple bivariate autoregression depicted in Figure 3. This necessarily assumes away statistically significant differences in other characteristics, thereby raising the real possibility of omitted relevant variables bias. On the other hand, parametric methods of estimating these recursion diagrams must use high order polynomials of the lagged asset holdings, along with proper controls for life cycle effects that naturally influence observed asset dynamics – people accumulate assets during their working adult lives and then begin divesting assets in their latter years – and for community-and-period-specific effects, in order to allow for multiple equilibria.[18] Such estimation is simply not feasible in most panel data sets. And even when it is, it can still be very difficult to fit complex nonlinear dynamics parametrically, as we show momentarily.

As a check on the robustness of the basic pattern, we therefore also estimated herd dynamics in Dirib Gombo and Ng'ambo parametrically. More precisely, we regressed the year-on-year change in household i's per capita herd size on a fourth-order polynomial in one-year lagged herd size,

$$A_{it} = \alpha_1 Y_{it} + \alpha_2 Y^2_{it} + \beta_1 A_{it-1} + \beta_2 A^2_{it-1} + \beta_3 A^3_{it-1} + \beta_4 A^4_{it-1} + \boldsymbol{\delta}_\mathbf{t} + \boldsymbol{\lambda}_\mathbf{i} + \varepsilon_{it} \qquad (6)$$

where Y is the household head's age in years, entering quadratically to control for life cycle effects, and the bold-faced vectors $\boldsymbol{\delta}$ and $\boldsymbol{\lambda}$ represent period- and household-specific effects, respectively. The regression results (available from the authors by request) imply a modest,

[17] Previous animal science and ethnographic research similarly suggests 4.5 TLU per capita as a threshold for the minimum amount of livestock necessary to provide adequate nutrition for an individual surviving on livestock in arid lands, based on productivity estimates and approximate caloric needs (Pratt and Gwynne 1977; Fratkin and Roth 1990).

[18] A third order polynomial (i.e., cubic) in the lagged asset stock is an absolute minimum to allow for the possibility of multiple stable equilibria; and that only permits two stable equilibria on the tails of the sample data.

statistically significant steady increase in herd size as a household head ages, peaking at age 53 before declining again. Of more immediate interest to the present analysis, the regression point estimates suggest stable dynamic equilibria at 0.35 and 7.83 TLU per capita and an unstable equilibrium at 6.08 TLU per capita. The lower estimated equilibrium herd size is strikingly similar to that derived through the simpler, bivariate nonparametric regression shown in Figure 7. The unstable equilibrium is statistically significantly higher and the higher-level stable equilibrium is statistically significantly lower than the counterpart estimates from the nonparametric regression. But as the plot of the parametrically fitted expected herd dynamics in Figure 3 (depicted by the line with + markers) shows, even a fourth-order polynomial seems to oversmooth the estimated asset dynamics in the upper tail of the wealth distribution, underscoring the value of nonparametric statistical methods in studying potentially complex nonlinear asset dynamics. Clearly, more work needs to be done to identify such thresholds confidently with an appropriate balance between flexibility of functional form and control for other covariates. Nonetheless, the hypothesis of multiple herd size equilibria among these pastoralists, consistent with the poverty traps hypothesis, appears robust.

One advantage of studying such patterns among pastoralists is that one can reduce wealth to herd size without doing much violence to the underlying reality.[19] In order to replicate this analysis in our other sites, where more favorable agroecology leads to more diversified crop and animal agriculture and where higher population densities lead to greater propensity to own nonagricultural assets and businesses, we need an alternative method for summarizing assets.

[19] Nonetheless, with increasing voluntary sedentarization of educated and employed pastoralists (McPeak and Little forthcoming), using herd size as a proxy for overall wealth is becoming increasingly suspect even in pastoral areas with little crop agriculture or nonagricultural industry.

The asset index introduced by Sahn and Stifel (2000) provides one method for doing precisely this.[20] The Sahn-Stifel asset index reflects a latent "wealth" variable common to most assets, providing a summary statistic of general wealth manifest in a range of assets. This method conserves degrees of freedom relative to including a long laundry list of assets and lends itself to graphical presentation in a way multi-dimensional asset measures do not.

We computed Sahn-Stifel asset indices separately for each site, pooling data across sample periods so as to be able to apply a consistent set of weights across periods, but adding period-specific dummy variables so as to account for temporal changes that might otherwise influence asset weights. We then used the resulting factor weights to compute household-and-period specific asset indices. These are unitless measures with unconditional site-specific means equal to zero due to the normalized weights of the asset index. So we cannot compare levels across sites, since the weighting schemes and normalizations are not comparable. We can, however, study household-specific asset dynamics using these asset indices just as we studied herd dynamics among northern Kenya pastoralist households.

Figure 4 presents the nonparametric autoregressions of household-specific asset indices for the three other sites. The two Malagasy sites do not appear to exhibit multiple equilibria in asset index dynamics. But in Madzuu, our western Kenya site, multiple dynamic equilibria appear to exist, with one at the upper reaches of the current wealth distribution and another around the mean of the current wealth distribution. If we run the simple ordinary least squares regression of real per capita daily income on the asset index and then calculate the predicted value at the dynamic asset equilibria, we find that these dynamic asset equilibria correspond to

[20] The Sahn-Stifel method uses factor analysis to find a single common factor that explains the covariance of a vector of assets under the assumption that these assets reflect a common, latent wealth variable that we cannot directly measure. The resulting factor loadings then represent data-driven weights on the assets. The product of these weights and a given household's asset holdings yields an intuitive, unitless asset index.

expected real per capita daily incomes of \$0.51 in the lower equilibrium, just beneath Kenya's rural poverty line, and \$1.48 in the upper equilibrium, hardly wealthy but nonetheless nearly three times higher than the lower equilibrium and the relevant poverty line. Again, the data appear consistent with the poverty traps hypothesis.

If multiple dynamic equilibria exist, households should converge toward these equilibria, leading to a mode in the cross-sectional distribution around the stable dynamic equilibria (Barrett forthcoming). Because households should not remain long at or near unstable equilibria, observed density at those points should be less than at the nearest stable equilibria. If there are multiple equilibria, then there should therefore appear more than one local mode in the cross-sectional income distribution, Quah (1996) referred to as "twin peaks", although there could in principle be more than two such local modes.[21] We see precisely this pattern of multi-peaked income distributions in Figure 5, whose peaks match up reasonably well against the incomes implied by the asset index dynamics (Figure 4). It certainly appears that multiple equilibria exist in Madzuu, with less than one-quarter of the population clustered around the higher dynamic equilibrium and the rest distributed around, and presumably converging toward, the lower level equilibrium beneath the poverty line.

As suggested in Figure 4, the chronically poor in Madzuu hold limited assets. Table 3 shows household mean asset holdings by categories from the poverty transition matrix (Table 1). Those who were poor in both two survey rounds, on average, had smaller asset bases – land, improved or cross-bred dairy cattle or access to off-farm employment earnings — than either the transitorily poor or, especially those households who were consistently non-poor, although the differences are only statistically significant between the chronically poor and the consistently

[21] Quah (1996) first remarked on this in the context of empirical macroeconomics, referring to the phenomenon of "twin peaks" reflecting two distinct dynamic equilibria. More generally, "multi-peakedness" provides prima facie evidence of multiple dynamic equilibria inconsistent with the hypothesis of unconditional convergence.

non-poor. This reinforces the impression that initial asset conditions affect poverty dynamics, consistent with the poverty traps hypothesis. [22]

## 5. Does Income Immobility Signal Poverty Traps?

So why do there appear to be multiple structural dynamic equilibria in at least the rural Kenya sites? In this section we explore this question further. We look in turn at whether there might exist measurable differences in risk management strategies by ex ante household wealth, and whether there might be locally increasing returns on assets due to discrete shifts in livelihood strategies or production technologies, both phenomena suggested by the qualitative evidence.

### A) Wealth-Differentiated Risk Management

The considerable short-term income volatility manifest in the data series from each of our sites raises important questions about poor households' capacity to undertake consumption smoothing. This is of interest for its own sake, as consumption smoothing is intrinsically valuable for households exhibiting risk aversion. But understanding more about households' management of income volatility also offers us a window into prospective sources of differential expected returns on assets, as is implied by a poverty traps explanation of persistent poverty.

A small literature demonstrates that in the presence of highly stochastic income, risk preferences, subsistence constraints or both can induce poorer households to trade off expected income growth for reduced income volatility, relative to wealthier households (Rosenzweig and Binswanger 1993, Carter 1997, Bardhan et al. 2000, Zimmerman and Carter 2003). Of course, if this means that poor households eschew the risks inherent to investment, this can lead

[22] Gamba et al. (2004) likewise find that initial assets, particularly land holdings and educational attainment, are negatively related to the likelihood of being poor in multiple periods in their rural Kenya panel data.

households to precisely the sort of low-level equilibrium posited by the poverty traps hypothesis. If this wealth-differentiated portfolio choice phenomenon is true, then we should see a lower coefficient of variation (CV)[23] of income among poorer households than among wealthier households, corresponding to the risk-return tradeoffs predicted by standard economic assumptions about preferences characterized by decreasing absolute risk aversion. Poor households should have lower expected returns on assets and a disproportionately lower variability in those returns.

Furthermore, poor households may be more likely to destabilize consumption as part of their strategy to cope ex post with uninsured and unmitigated income risk, precisely so as to avoid having to divest scarce productive assets on which future well-being – or even survival – depends. This implies that poorer households may have higher coefficients of variation in consumption (expenditure) than do richer households. Richer households will have more savings (in cash and in kind, including in the form of productive assets) and more access to credit, so they will have more opportunity to smooth consumption ex post of stochastic income realizations than do poorer households.

The combination of these two hypotheses raises an interesting possibility. If income variability increases with wealth but consumption variability decreases with wealth, that implies that consumption smoothing increases in expected income. If consumption smoothing increases welfare due to risk aversion, and if poorer households indeed smooth consumption less than wealthier households – i.e., if consumption smoothing is a normal good, increasing in income or wealth – then standard, static expenditure measures will tend to understate welfare differences because they omit the positive value of smoother consumption.

---

[23] Coefficient of variation, a unitless measure or risk, equals the standard deviation divided by the mean.

To the best of our knowledge, the hypothesis that wealth has opposing effects on the volatility of consumption and of income has not yet been empirically tested perhaps because this requires sufficiently high frequency data to establish the volatility of both income and expenditures. Fortunately, with ten quarterly observations per household, our northern Kenya data are suitable for this task. The data cannot support testing this hypothesis in our other sites. Using data from all six of the PARIMA sites in northern Kenya, we computed 177 household-specific coefficients of variation for quarterly income and expenditure series.[24]

Figure 6 plots the nonparametric regression of these CVs on initial period household herd size, expressed in per capita TLU. The positive correlation between wealth and income risk is apparent in the upward slope of the thinner solid line depicting income CV. Bootstrapped confidence bands (not shown) indicate that the positive slope to this regression line is indeed statistically significant over most of the conditioning domain. Poorer households indeed appear to systematically suppress income variability. One would expect this to come at a cost of lower expected marginal returns on assets. As we show in the next sub-section, these data support that hypothesis as well.

The thicker solid regression line reflects the relationship between the CV of expenditure and household wealth. This slopes modestly downward, although bootstrapped confidence bands (not shown) indicate that the differences are only statistically significantly different between the tails of the wealth distribution. The gap in Figure 6 between the income and expenditures CV regression lines reflects consumption smoothing behavior. While richer households take on greater income risk than poorer households do, they nonetheless enjoy lower intertemporal

[24] Because we have to compute household-specific estimates of income and expenditure coefficients of variation, we lose the time series variation on which site-specific regression estimation depends in our northern Kenya locations of Dirib Gombo and Ng'ambo. So for this analysis we pool the data with those from households in the four other northern Kenya PARIMA survey sites, which are described in Barrett et al. (2004).

variability in expenditures. Consumption smoothing indeed appears to be a normal good among these households, increasing in wealth in spite of prospectively greater absolute risk aversion among the poor.

The dashed curve, which should be read against the righthand vertical axis, depicts the empirical wealth density depicting the asset distribution among surveyed households. Among the poorest households – up to roughly the median of the wealth distribution – mean intertemporal income variability is actually less than mean expenditure volatility, signaling that the most vulnerable households indeed seem not to smooth consumption at all, but to destabilize consumption in order to protect crucial productive assets on which their future survival depends. This underscores the dynamic welfare cost of uninsured risk borne by vulnerable households. Consumption smoothing appears to increase relatively rapidly as one moves above the median of the wealth distribution among these northern Kenya pastoralists.

B) Locally Increasing Returns on Assets

If poorer households trade lower risk for lower returns, this should appear as well when we plot expected income against assets. Figure 7 presents the nonparametric kernel regression of per capita daily income per capita herd size using the same 177 northern Kenya households. The increasing slope of the income function over most of the wealth distribution signals increasing returns per unit wealth, as would be expected if households are indeed taking on higher risk – higher reward portfolios of activities and assets as their wealth increases. Of course, this creates multiple dynamic equilibria based on initial wealth, consistent with the S-shaped asset dynamics identified in the previous section. The marginal rate of increase in expected income (the slope of the income function) does not begin to decrease until about the 96$^{th}$ percentile of the wealth distribution – corresponding with the higher stable dynamic equilibrium in Figure 3. Over most of the wealth distribution, there appear to be increasing returns to asset holdings.

This raises the obvious question: if expected returns are increasing in livestock holdings over most of the wealth distribution in the northern Kenya pastoralist sites we study, why don't poorer households accumulate assets so as to increase expected income? It would seem that there must be some barrier(s) to accumulation. The explanation already discussed concerns portfolio choice based on risk preferences that differ across the wealth distribution. The data appear consistent with that claim. But there may be alternative or supplementary explanations.

One candidate explanation would be subsistence constraints that limit households' ability to reduce current consumption in order to increase savings and thus asset accumulation. Unfortunately, we have no good way to test directly for subsistence constraints in our data. The data do show, however, that all of these households received food aid in at least some period and that many suffer acute food insecurity manifest in coping behaviors such as reduced frequency of meals, in many households to just one a day.

Another plausible, complementary explanation arises from the lack of liquid savings and credit. Although there are bank services in the larger towns of northern Kenya and there have been efforts at promoting microfinance institutions in several of the survey communities, fixed fees at KCB make real rates of return negative on small accounts and loan limits at existing microcredit institutions preclude purchasing fertile large ruminants for herd building (Osterloh 2004). Less than 15 percent of the survey households hold bank accounts and access to credit is negligible. Given scant cash holdings or credit, very few households purchase animals; herd accumulation involves almost exclusively biological reproduction (Osterloh et al. 2003). To a certain extent, then, households' asset holdings may be constrained to follow the natural population dynamics of their livestock assets

The phenomenon of locally increasing returns on assets appears in all of our sites for at least some assets, but with variation in degree across years and locations. To get at the hypothesis in a different way, we ran the ordinary least squares regression of household income on a range of household assets for each location and year separately using a generalized quadratic, second-order flexible functional form to allow for nonlinearities and interaction effects among assets,[25] then computed the estimated marginal returns on assets and ran the nonparametric LOESS regression of those estimated marginal effects on the asset stock. The results underscore a pattern of locally increasing returns to several key assets in many of our sites.

Consider, for example, Figure 8, which depicts the nonparametric regression of estimated marginal returns to labor force (measured as working age adults in the household) and to the amount of rice land area a household owns on household stock of labor and rice land, respectively.[26] These regressions depict the potentially endogenous returns on assets, as permitted in equation (2). The upper left panel of Figure 8 shows that the estimated marginal returns on household labor stock are increasing significantly around the middle of the labor distribution in Fianarantsoa, the poorer of our Malagasy sites, where illness and migration limit labor availability for many poor households, commonly impeding expansion into higher return, labor-intensive activities such as dairy production or SRI rice production.[27] Few households in

[25] Detailed regression results and diagnostics are available from the authors by request.

[26] In Madagascar, "rice land" (*bas fond* or *tanimbary*) is irrigable lowland suitable for cultivation of rice. It is distinct from the upland (*tanety*) that is purely rainfed. The underlying regression coefficients for the variables discussed are statistically significantly different from zero at the five percent level. Marginal returns were then estimated for each household using the point estimates from the second order generalized quadratic specification – normalized to produce an exact second-order approximation at the sample means – and the household-specific asset stock values. Here we report only the 1997 results. The 2002 data yield qualitatively identical patterns.

[27] The system of rice intensification (SRI) was developed in Madagascar in the late 1980s and has demonstrated tremendous potential for yield growth without requiring any new seed, chemical fertilizer or other purchased inputs.

Fianarantsoa have cash savings, access to credit or steady cash income from salaried employment to use to hire unskilled workers when they (perhaps temporarily) suffer labor shortages that might impede adoption of an improved technology or that might cause agricultural yield losses due to mistiming of field operations (e.g., due to a spell of malaria). Liquidity constraints make labor availability a critical determinant of household livelihood strategies. Those households that lose an adult to death or migration (without compensating remittances) thus lose not only a productive worker but also suffer average productivity losses among the remaining adults, reflecting the endogenous asset returns characteristic of poverty traps. Interestingly, this effect is not present in the wealthier Vakinankaratra site, where widespread off-season cropping and salaried employment and better access to markets and credit enable households to hire labor more freely in response to latent demand. The result is diminishing returns to labor, as shown in the upper right panel of Figure 8.

The marginal returns to rice land likewise exhibit locally increasing returns in Fianarantsoa. It is almost exclusively the households with the largest lowland rice area who adopt SRI, apply fertilizer or manure or use animal traction. Estimated marginal income per unit area of rice land owned is thus sharply increasing in the upper third of the land distribution as the largest farms enjoy the highest rice yields. The locally increasing returns evident in the poorer Fianarantsoa site are again absent in the better-off Vakinankaratra region, where even small farmers are commonly able to secure off-season contract farming that provides fertilizer inputs and where water management is relatively reliable, maintaining reasonable yields even on smaller farms.

---

SRI generates these effects through a suite of changes in agronomic practices in plant spacing, timing of seedling transplanting and soil moisture management. However, SRI requires additional initial labor investment that typically puts it out of reach of the poorest and smallest households. Moser and Barrett (2003) document these effects, while Barrett, Moser, McHugh and Barison (2004) document that SRI increases yields on average by more than 80 percent, holding farmer and plot characteristics and other inputs constant, while also increasing yield risk, providing a link to the preceding sub-section on wealth-differentiated risk management strategies.

The argument we advance here is subtle. We do not claim that there exist globally increasing returns to any particular asset, nor even that locally increasing returns exist everywhere. Rather, our point is that there exist places where market failures – perhaps especially in the finance necessary to undertake investment or to cope with shocks without liquidating productive assets – can lead to sharp differences in productivity among reasonably similar households and thus to poverty traps. In less-favored areas such as the rangelands of northern Kenya and the southern highlands of Madagascar, such phenomena seem to exist, while we do not find evidence of similar patterns in the more favored area of Madgascar's central highlands.

This quantitative evidence corresponds with the qualitative evidence from our in-depth interviews with a subsample of farmers and participatory focus group discussions about local definitions, dynamics and responses to poverty. The prevailing view within the community is that those who manage to complete their secondary education and secure salaried employment through social connections or good fortune – education is merely a necessary condition to finding a decent job, but by no means is it sufficient – can then build and sustain a reasonable livelihood, with improved dairy cattle and tea bushes on several acres of land in addition to – and in large measure because of – steady non-farm cash income. Each of the households we interviewed who were nonpoor in both 1989 and 2002 emphasized nonfarm employment as playing a crucial role in their achievement and maintenance of an adequate standard of living.

Equally important, an adequate livelihood is vulnerable to shocks in Madzuu. Overwhelmingly, health shocks were the most frequent reason given for households falling into poverty, cited by nearly every Madzuu household we spoke with that was poor in 2002.[28] Health and mortality shocks may cause a loss of permanent salaried employment or self-employment,

[28] Krishna et al. (2004) and Kristjanson et al. (2004) similarly find health shocks to be overwhelmingly the most common explanation for households falling into poverty in their study of a broader cross-section of western Kenya.

ending a household's steady cash flow and often necessitating distress sale of productive agricultural and household assets to pay for medical expenses. Even transient health shocks – most commonly malaria in this area – can lead to significant yield losses because they prevent the application of labor at crucial periods during the rainy, growing season, when illnesses are most common. These yield losses can reduce consumption over the subsequent year, leaving the household more vulnerable to further disease, thereby igniting a vicious cycle of disease and destitution.[29] In other cases, the death of a close family member – a father, brother or spouse – imposed funeral expenses on a household that wiped out its assets, causing it to pull children from school and thus breaking the household's long term access to remunerative employment.[30]

Retrenchment in Kenya's off-farm labor market, due in considerable measure to reduced public sector employment and to infrastructure decline that has hurt rural non-farm industry throughout the country, has affected the accessibility of the higher-level equilibrium. Madzuu residents repeatedly told us that fifteen or twenty years ago, secondary school leavers could almost always find remunerative employment. That is no longer true. The result of lower off-farm skilled labor demand relative to supply has had multiple adverse effects in communities such as Madzuu. First, there are the obvious, direct labor market effects: greater unemployment and lower real wages, both skilled and unskilled (the latter because skilled workers who fail to find salaried employment commonly join the unskilled labor market, expanding supply there as well). The indirect impacts have likewise proved important, according to the households we interviewed. Less off-farm employment has reduced outmigration from Madzuu, leading to

[29] Tegemeo/MSU (2001) study on health shocks and productivity and income find qualitatively identical patterns using a far larger panel data set from 24 rural districts in Kenya.

[30] Freudenberger (1999) offers a hauntingly similar narrative of a vicious cycle wrought by local custom regarding funeral expenses. Based on participatory poverty assessments in forest communities in Fianarantsoa, she found that ritual slaughter of livestock in Betsileo culture had driven many families from stable livelihoods into destitution, as the loss of cattle reduced draught power and manure, both essential inputs to the intensive terraced rice cultivation practiced in these communities.

increased on-farm population density. The result has been farm partitioning, manifest in sharp declines in average farm sizes, reduced fallowing and as a direct consequence, accelerated soil nutrient depletion. Uniformly, respondents report that farms in Madzuu are now smaller and less fertile than they were a generation ago. Perhaps more remarkably, Madzuu residents routinely make the sophisticated connection between land and labor markets, observing that adverse changes in local land quality follows in large measure from the lack of growth in off-farm labor demand for a growing rural population.

## 6. Conclusions and Policy Implications

In order to make progress in combating persistent poverty, policymakers must have a clear and accurate conceptualization of the causal mechanism that keeps people poor indefinitely. In particular, the increasingly popular term "poverty traps" implies a quite different mechanism behind poverty than do prevailing economic theories of growth and development. This paper offers a novel attempt at establishing empirically whether there might really exist poverty traps in the form of multiple dynamic equilibria, with households attracted toward low-level equilibria when they start with limited initial wealth or when they suffer a serious shock to the stock or productivity of their assets.

The results are striking. Our data from rural Kenya and Madagascar offer consistent support for the poverty traps hypothesis, finding that structural income and asset dynamics exhibit multiple stable dynamic equilibria in several sites, especially in lower potential and remoter regions. Both quantitative and qualitative evidence support these inferences.

Why might poverty traps exist? We offer a few tentative results in the direction of explaining this phenomenon, but we cannot confidently establish the causality behind these phenomena. We find evidence that marginal returns on assets are positively correlated with initial wealth in some places and over some ranges of asset holdings. Such locally increasing returns also lead to divergent growth patterns and to poverty traps for those facing locally diminishing marginal returns on their meager asset stocks. This seems to occur because households with fewer productive assets tend to be excluded from higher-return livelihood strategies due to cash liquidity constraints, social exclusion, or both. We likewise find evidence that considerable risk exposure leads to wealth-differentiated risk management, with the relatively wealthy able to smooth consumption and take on higher risk-higher return livelihoods. Meanwhile, poorer households have to destabilize consumption so as to protect scarce, crucial productive assets and they choose lower risk-lower return livelihoods. This predictably leads to observable divergence in household-level asset and structural income dynamics.

So what are the key policy implications of these findings? First, macroeconomic and sectoral reforms alone are likely insufficient to put poorer populations on a sustainable growth trajectory. Less-favored areas and the poorest households need more direct intervention to build and protect assets and to improve the productivity of households' existing asset stocks, or to remove the barriers (e.g., access to credit, insurance and savings products) that exclude the poorest households and regions from accumulation processes. Such interventions can induce natural asset accumulation and income growth. The most appropriate assets to build will depend on local context. In the northern Kenyan rangelands, livestock are (not surprisingly) the key asset and our evidence suggests a critical threshold at 5-6 TLU per capita. In that context, it seems critical to build herds to that size, perhaps most cost-effectively by lowering the critical threshold through, for example, improved veterinary care, physical security of herds and herders, and dry season water availability. In the southern Madagascar highlands, it would appear the persistently poor could be helped considerably by improving preventive and curative health care so as to prevent households from losing precious adult workers, relieving seasonal liquidity constraints that impede uptake of improved rice production methods, and facilitating adoption and marketing of higher-value fruits, vegetables and dairy products.

Second, bifurcation in accumulation and risk management patterns must originate in one or more exclusionary process that prevents poorer households from choosing more remunerative livelihood strategies. Some of this exclusion may be geographic, as certain production strategies are infeasible in particular areas due to soil and hydrological conditions, available infrastructure, access to markets, and demand for skilled labor. In other cases, the exclusion may result from household-level barriers to entry associated with limited access to credit or insurance, educational attainment or other critical assets. We cannot probe these issues adequately here. Our objective, rather, is to call attention to the emerging evidence that poverty traps indeed seem to exist and we must redouble efforts to understand and combat them where they exist.

Third, effective safety nets to protect the assets households accumulate can prevent inadvertent back-sliding. Such safety nets need to be located strategically just above the critical asset thresholds at which expected income dynamics birfurcate. This calls for a somewhat broader conceptualization of safety nets than simply the nutrition-focused, food aid-based safety nets prevalent in policy discussions today. Protecting human health through adequate nutrition and ensuring children stay in school (e.g., through food-for-education projects) is indisputably important and may suffice where one need only maintain access to labor markets in order to grow out of poverty. But in the rural sites we study, health shocks largely unrelated to nutrition – e.g., HIV/AIDS, malaria, tuberculosis – are the most common reason households become and stay poor, underscoring the importance of preventive and curative health care quite apart from support for adequate access to food. Moreover, labor is not the only critical productive asset. A number of recent studies have pointed, in particular, to the importance of losses of livestock in explaining households' decline into poverty (Freudenberger 1998, Krishna et al. 2004, Kristjanson et al. 2004), results echoed in our own qualitative and quantitative results. This underscores the importance of developing insurance and other means to help poor households manage risk due to theft, climate and civil strife.

Much remains to be learned. Our results are by no means definitive. But they offer some innovative ways to investigate the causal mechanism underpinning chronic poverty in Africa and how communities, governments and donors can most effectively combat persistent poverty.

**References**

Alderman, H., J. Behrman, H. P. Kohler, J.A. Maluccio, and S. Watkins (2001) "Attrition in Longitudinal Household Survey Data: Some Tests for Three Developing-Country Samples" *Demographic Research* 5:78-124.

Bardhan, P., S. Bowles and H. Gintis (2000), "Wealth Inequality, Wealth Constraints and Economic Performance," in A. B. Atkinson and F. Bourguignon, eds., *Handbook of Income Distribution, Volume 1*, (Amsterdam: Elsevier Science).

Barrett, C.B. (forthcoming), "Rural Poverty Dynamics: Development Policy Implications," *Agricultural Economics*.

Barrett, C.B., G. Gebru, J.G. McPeak, A.G. Mude, J. Vanderpuye-Orgle, and A.T. Yirbecho, "Codebook For Data Collected Under The Improving Pastoral Risk Management on East African Rangelands (PARIMA) Project," May 2004.

Barrett, C.B., C.M. Moser, O.V. McHugh and J. Barison (2004), "Better Technology, Better Plots or Better Farmers? Identifying Changes In Productivity And Risk Among Malagasy Rice Farmers," *American Journal of Agricultural Economics*, 86 (4): 869-888.

Barrett, C.B., T. Reardon and P. Webb (2001), "Nonfarm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics and Policy Implications," *Food Policy* 26 (4): 315-331.

Barrett, C.B. and B. Swallow (2003), "Fractal Poverty Traps," Cornell University working paper.

Baulch, B. and J. Hoddinott (2000), *Economic Mobility and Poverty Dynamics in Developing Countries*. London: Frank Cass.

Baumol, W. J. (1986), "Productivity Growth, Convergence, and Welfare: What the Long-run Data Show," *American Economic Review* 76(5): 1072-85.

Carter, M.R., (1997), "Environment, Technology and the Social Articulation of Risk in West African Agriculture," *Economic Development and Cultural Change* 45(2):557-590.

Carter, M.R. and C.B. Barrett (2004), "The Economics of Poverty Traps and Persistent Poverty: An Asset-Based Approach," Cornell University working paper.

Carter, M.R. and J. May (2001). "One Kind of Freedom: The Dynamics of Poverty in Post-Apartheid South Africa," *World Development* 29, 12: 1987-2006.

Deininger, K. and J. Okidi, (2003). "Growth and poverty reduction in Uganda, 1992– 2000: panel data evidence," *Development Policy Review* 21 (4), 481– 509.

Dercon, S. (2004). "Growth and shocks: evidence from rural Ethiopia, "*Journal of Development Economics* 74 (2): 309-329.

Elbers, C., J.W. Gunning and B.H. Kinsey (2002), "Convergence, Shocks and Poverty," Tinbergen Institute Working Paper 2002-035/2.

Falaris, E. (2003), "The Effect of Survey Attrition in Longitudinal Surveys: Evidence from Peru, Cote d'Ivoire, and Vietnam." *Journal of Development Economics* 70, 1: 133-157.

Fratkin, E. and E. A. Roth. (1990). "Drought and Economic Differentiation Among Ariaal Pastoralists of Kenya." *Human Ecology* 18, 4:385-402.

Freudenberger, K.S. (1998), "Livelihoods Without Livestock: A Study of Community and Household Resource Management in the Village of Andaladranovao, Madagascar" USAID Landscapes Development Initiative project report.

Gamba, P., T. Jayne and E. Mghenyi (2004), "Rural Poverty Dynamics, Agricultural Productivity and Access to Resources," Tegemeo Institute of Agricultural Policy and Development working paper.

Gunning, J.W., J.Hoddinott, B. Kinsey and T. Owens (2000). "Revisiting forever gained: Income dynamics in the resettlement areas of Zimbabwe, 1983– 1997," *Journal of Development Studies* 36, 131– 154.

Jalan, J. and M. Ravallion (2002). "Geographic poverty traps? A micro model of consumption growth in rural China." *Journal of Applied Econometrics* 17, 329– 346.

Jalan, J. and M.Ravallion (2004). "Household income dynamics in rural China," in S. Dercon, ed., *Insurance Against Poverty*. Oxford: Oxford University Press.

Jayne, T.S., T. Yamano, M.T. Weber, D. Tschirley, R. Benfica, A. Chapoto and B. Zulu, (2003) "Smallholder income and land distribution in Africa: implications for poverty reduction strategies", *Food Policy* 28 (3): 253-275.

Kenya Ministry Of Planning and National Development, 1998. *First Report on Poverty in Kenya*. Two Volumes. Central Bureau of Statistics, and the Human Resources and Social Services Departments, Nairobi, Kenya.

Krishna, A. (2003), "Escaping Poverty and Becoming Poor: Who Gains, Who Loses, and Why? Accounting for Stability and Change in 35 North Indian Villages," *World Development* 32(1): 121-136.

Krishna, A., P. Kristjanson, M. Radeny and W. Nindo (2004), "Escaping Poverty and Becoming Poor in Twenty Kenyan Villages," *Journal of Human Development*, in press.

Kristjanson, P., A. Krishna, M. Radeny and W. Nindo (2004), "Pathways Out of Poverty in Western Kenya and the Role of Livestock," Working paper for the FAO/Pro-Poor Livestock Policy Initiative.

Lybbert, Travis J., Christopher B. Barrett, Solomon Desta and D.Layne Coppock (2004), "Stochastic Wealth Dynamics and Risk Management Among A Poor Population," *Economic Journal* 114 (498): 750-777.

Mango, N., J. Cheng'ole, G. Kariuki and W. Ongadi (2004), "Social Aspects of Dynamic Poverty Traps: Cases from Vihiga, Baringo and Marsabit Districts, Kenya" BASIS CRSP research report.

McPeak, J. (2003), "Analyzing and Addressing Localized Degradation in the Commons. *Land Economics* 79, 4: 515-536

McPeak, J.G. and C.B. Barrett (2001), "Differential Risk Exposure and Stochastic Poverty Traps Among East African Pastoralists," *American Journal of Agricultural Economics,* 83: 674-679.

Minten, B. and M. Zeller (2000),*Beyond Market Liberalization: Welfare, Income Generation and Environmental Sustainability in Rural Madagascar*. Aldershot, UK: Ashgate.

Mistiaen, J., B. Ozler, T. Razafimanantena, and J. Razafindravonona (2002), "Putting Welfare On The Map In Madagascar," Africa Region Working Paper number 34, World Bank.

Moser, C.M. and C.B. Barrett (2003), "The Disappointing Adoption Dynamics of a Yield-Increasing, Low External Input Technology: The Case of SRI in Madagascar", *Agricultural Systems*, 76 (3): 1085-1100.

Osterloh, S. (2004), M.S. thesis, Cornell University.

Osterloh, S.M., J.G. McPeak, H. Mahmoud, W.K. Luseno, P.D. Little, G. Gebru and C.B. Barrett (2003), "Pastoralist Livestock Marketing Behavior in Northern Kenya and Southern Ethiopia: An Analysis of Constraints Limiting Off-Take Rates," Report to the USAID Global Livestock Collaborative Research Support Program.

Place, F., P. Hebinck and M. Omosa (2003), "Chronic Poverty in Rural Western Kenya: Its Identification and Implications for Agricultural Development," paper presented at conference on Chronic Poverty, University of Manchester.

Pratt, D. and M. Gwynne. (1977). *Rangeland Management and Ecology in East Africa*. Hodder and Stoughton, London.

Programme Ilo (2002), "Impact de la crise politique sur le bien-être des ménages: les résultats d'une évaluation par des focus groups communaux," Crise Politique policy brief no. 3.

Programme Ilo (2003), " Bien-être et sécurité alimentaire : Perceptions postcrise par des focus groups communaux," Juillet 2002, Policy brief Post-crise, no. 3

Randrianjatovo, J.-F. (2004), "Analyse descriptive de l'aspect qualitatif de la dynamique de pauvreté," FOFIFA report.

Ravallion, M. and J. Jalan (1996) "Growth divergence due to spatial externalities," *Economics Letters* 53 (2), 227–232.

Quah, D. (1996), "Twin Peaks: Growth and Convergence in Models of Distribution Dynamics," *Economic Journal* 106, 437: 1045-1055.

Rosenzweig, M.R. and H. Binswanger (1993), Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments," *Economic Journal* 103 (416): 56-78.

Sahn, D.E. and D.C. Stifel (2000), "Poverty Comparisons Over Time And Across Countries In Africa," *World Development* 28, 12: 2123-2155.

Zimmerman, F. and M.R. Carter (2003), "Asset smoothing, consumption smoothing and the reproduction of inequality under risk and subsistence constraints," Journal of Development Economics 71 (2): 233-260.

**Figure 1: Survey Sites in Rural Kenya and Madagascar**

Kenya


Madagascar


**1 = Madzuu (Vihiga)**

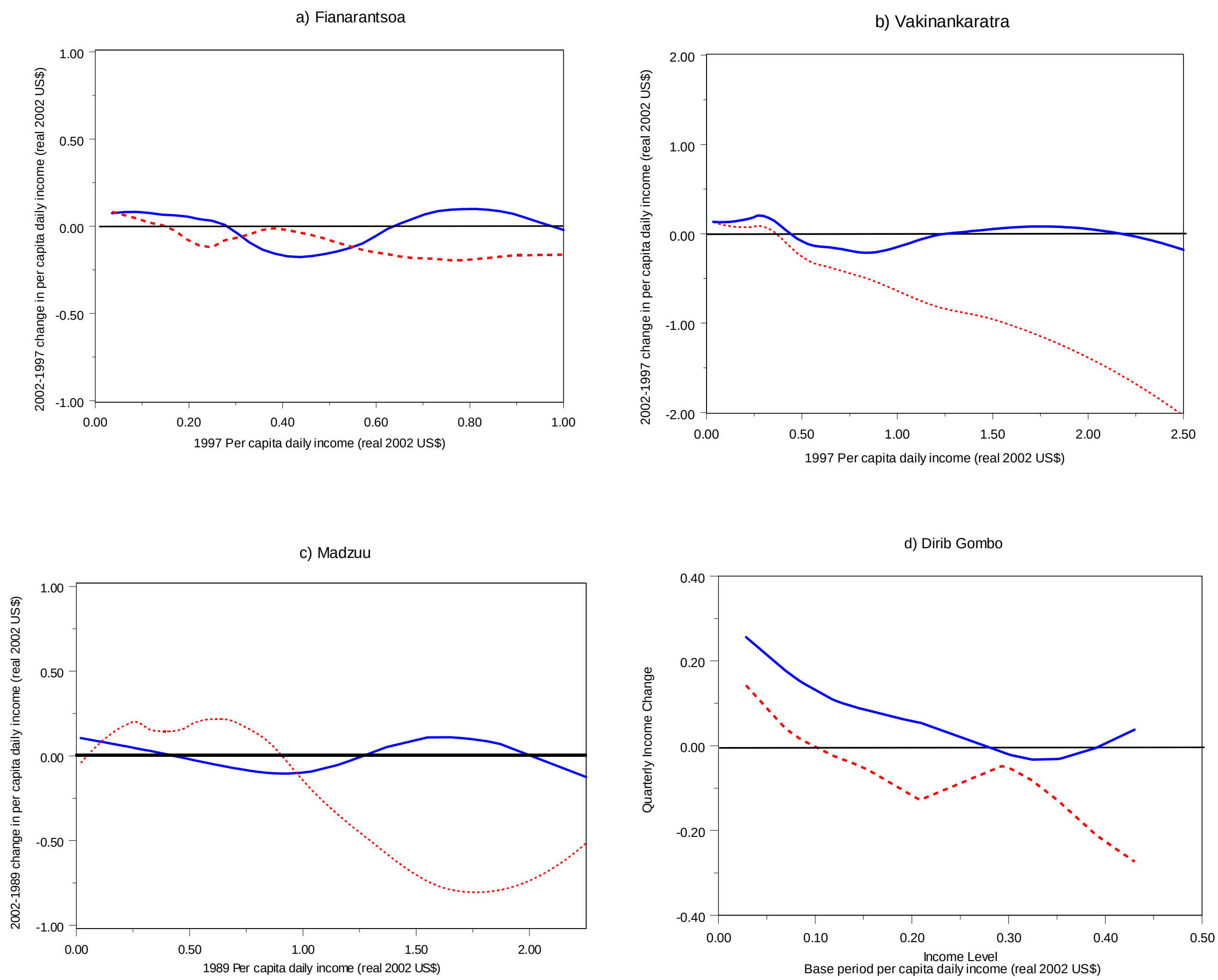
**2 = Ng'ambo (Baringo)**

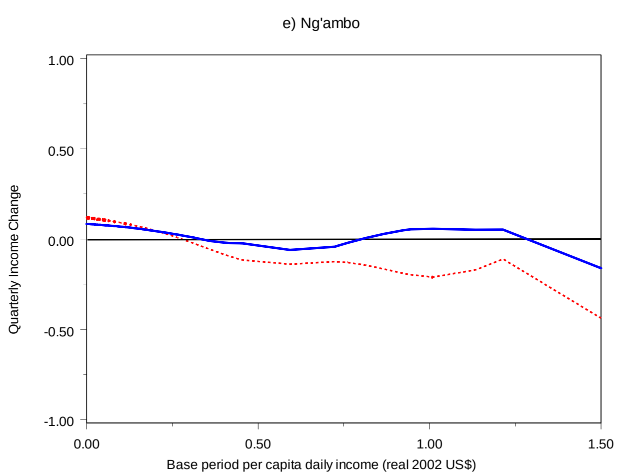
**3 = Dirib Gombo (Marsabit)**

**4 = Fianarantsoa**

**5 = Vakinankaratra**

**Figure 2: Site-specific filtered and structural income change regressions**




**In each panel, the red, dashed lines represent the nonparametric regression of total income change on beginning period income, while the blue, solid line represents the structural income dynamics regression of income change predicted econometrically from the regression of income on assets on beginning period income.**

**Figure 3: Herd Dynamics in Northern Kenya**

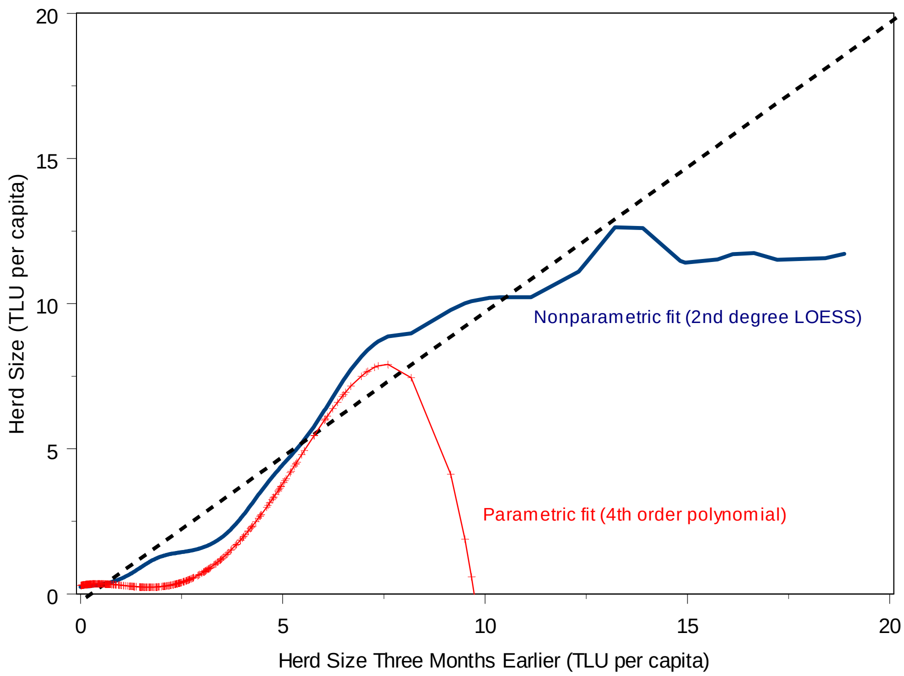



**Figure 4: Asset Index Dynamics**

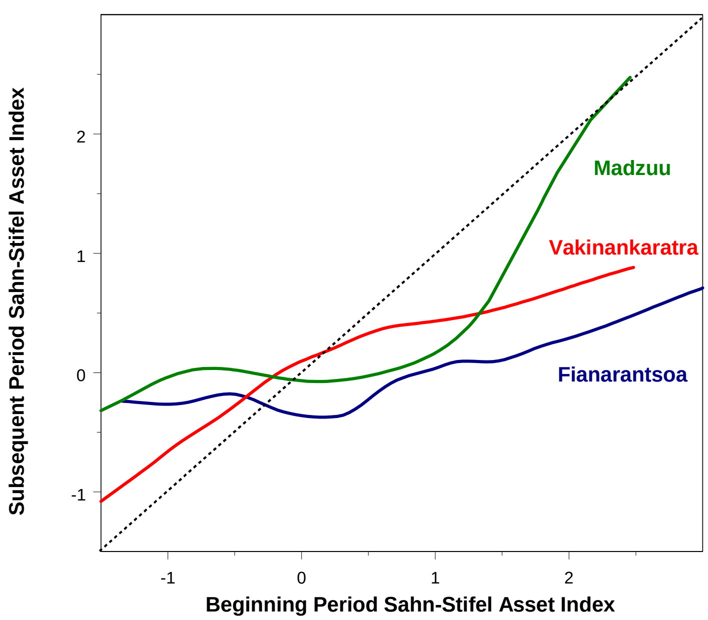


**Figure 5: 2002 Income Distribution in Madzuu**

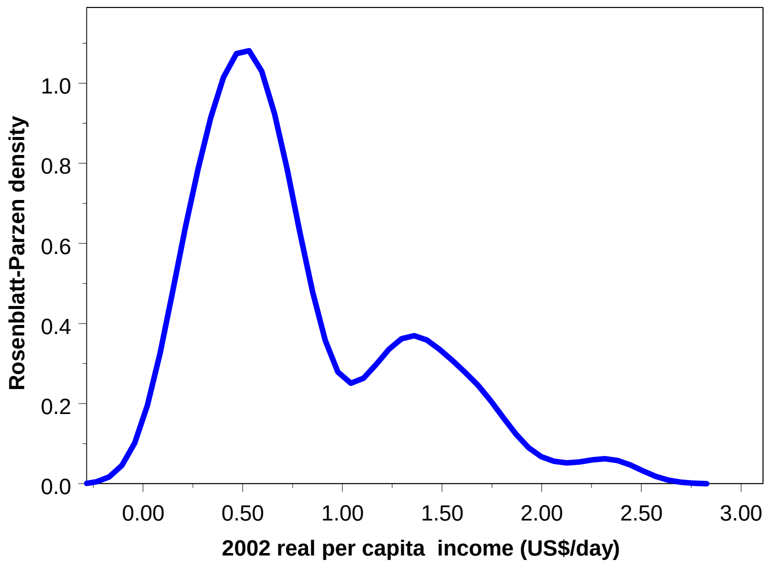


**Figure 6: Wealth-dependent risk management in northern Kenya**

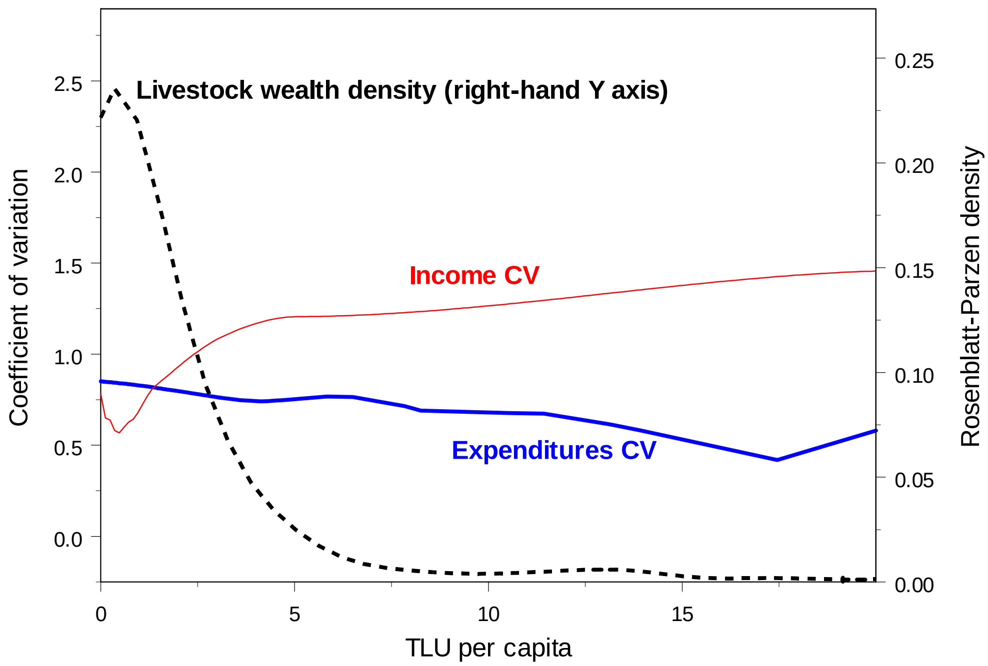



**Figure 7: Welfare – Herd Size Relation in northern Kenya**

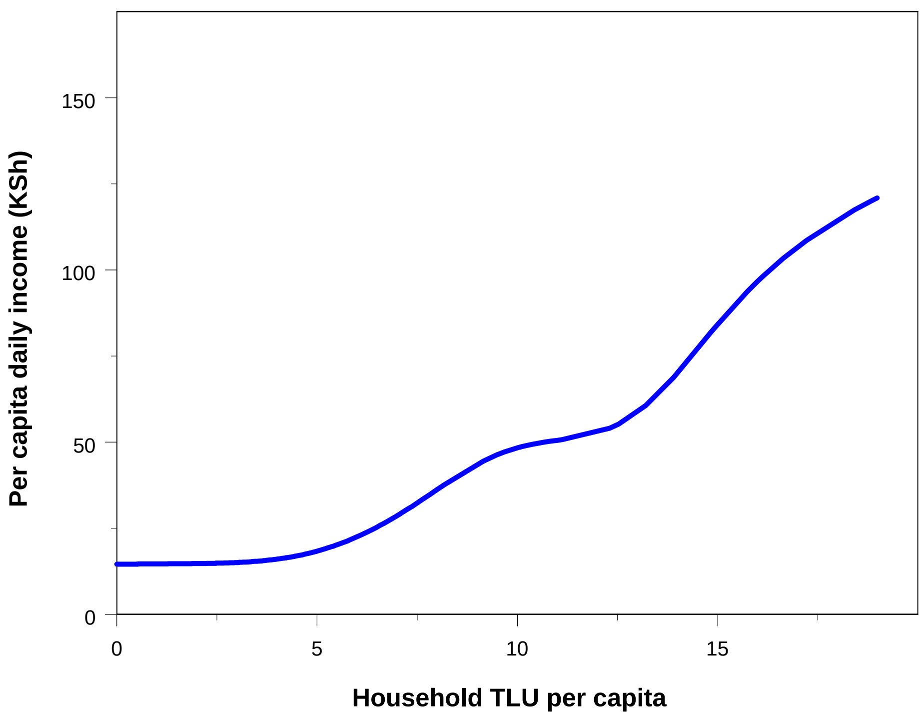
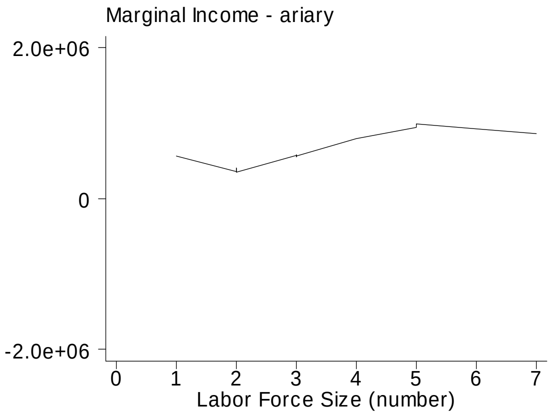


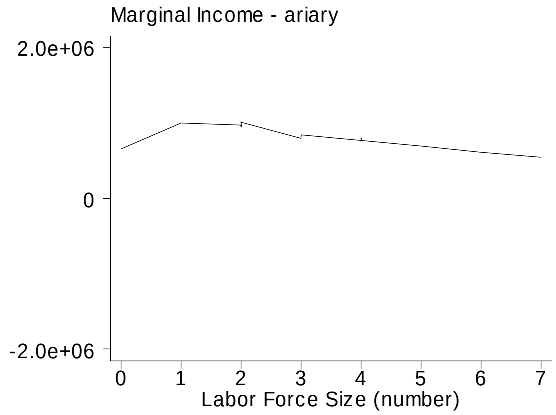
**Figure 8: Estimated Site-and-Year-Specific Returns on Assets, Madagascar**

Marginal Returns to Labor Force Size, 1997

Fianarantsoa

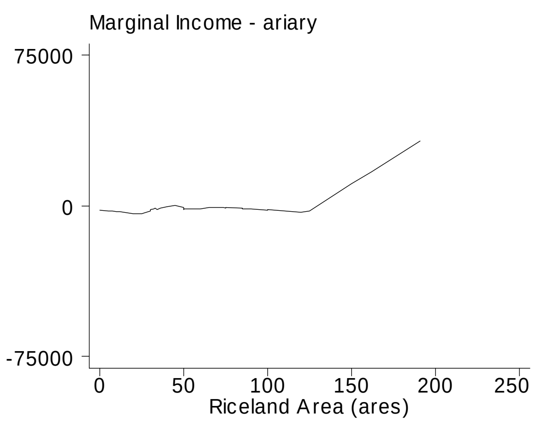



Vakinankaratra




Marginal Returns to Rice Land Area, 2002

Fianarantsoa




Vakinankaratra

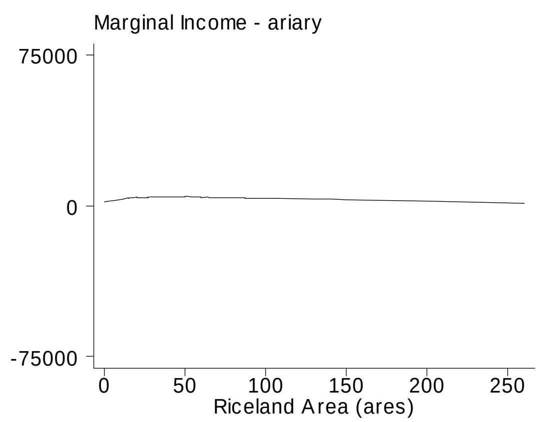


**Table 1: Ultra-Poverty Transition Matrices**
**As measured against $0.50/day per capita income ultra-poverty line**

| | Poor in Subsequent Period | | Non-Poor in Subsequent Period | |
|---|---|---|---|---|
| **Poor in Initial Period** | 2000-2002<br>Dirib Gombo<br>100.0%<br><br>**70.8%** | 1989-2002<br>Madzuu<br>60.7%<br><br>1997-2002<br>Fianarantsoa<br>82.8% | 2000-2002<br>Dirib Gombo<br>0.0%<br><br>**11.2%** | 1989-2002<br>Madzuu<br>20.2%<br><br>1997-2002<br>Fianarantsoa<br>10.3% |
| | 2000-2002<br>Ng'ambo<br>86.5% | 1997-2002<br>Vakinankaratra<br>58.5% | 2000-2002<br>Ng'ambo<br>9.0% | 1997-2002<br>Vakinankaratra<br>7.4% |
| **Non-Poor in Initial Period** | 2000-2002<br>Dirib Gombo<br>0.0%<br><br>**11.3%** | 1989-2002<br>Madzuu<br>10.1%<br><br>1997-2002<br>Fianarantsoa<br>6.9% | 2000-2002<br>Dirib Gombo<br>0.0%<br><br>**6.8%** | 1989-2002<br>Madzuu<br>9.0%<br><br>1997-2002<br>Fianarantsoa<br>0.0% |
| | 2000-2002<br>Ng'ambo<br>0.0% | 1997-2002<br>Vakinankaratra<br>22.3% | 2000-2002<br>Ng'ambo<br>4.5% | 1997-2002<br>Vakinankaratra<br>11.7% |

Within each transition matrix cell, the sites are presented in a two-by-two matrix, with the upper left reflecting sites with poor agroecological conditions and market access (Dirib Gombo), those on the upper right having poor market access but favorable agroecological conditions (Fianarantsoa, Madzuu), that on the lower left having favorable market access but poor agroecological conditions (Ng'ambo), and those on the lower right having favorable agroecological conditions and market access both (Vakinankaratra).

Bold red underlined number is the weighted average across all sites.

**Table 2: Estimated annual gross (net) poverty exit rates**

| | |
|---|---|
| Dirib Gombo: | 0.0% (0.0%) |
| Madzuu: | 2.2% (1.0%) |
| Fianarantsoa: | 2.3% (0.7%) |
| Vakinankaratra: | 2.4% (-4.2%) |
| Ng'ambo: | 5.2% (4.1%) |

**Table 3: 1989 Mean Asset Holdings, Madzuu**

| | *Chronically Poor* | *Transient: Poor to Non-poor* | *Transient: Non-poor to poor* | *Non-Poor* |
|---|---|---|---|---|
| *Farm size (acres)* | *0.81* | *1.00* | *0.97* | *2.41** |
| *Head of improved, cross-bred dairy cattle* | *0.06* | *0.11* | *0.11* | *0.25** |
| *Household includes secondary school graduate (1=yes, 0=no)* | *0.44* | *0.44* | *0.44* | *0.88** |
| *Family has off-farm employment earnings at least 10 months/year (1=yes, 0 =no)* | *0.26* | *0.22* | *0.33* | *0.38* |

* statistically significant differences at five percent level.